

**ENERGY OPTIONS
FOR CHIPEWYAN LAKE, ALBERTA**

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**Prepared for
Alberta Power Limited**

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SECTION 1.0 EXECUTIVE SUMMARY

Alberta Power Limited proposed that natural gas could provide an alternate fuel for use in their Chipewyan Lake Power Plant. The Power Plant currently uses diesel oil as a fuel. The use of natural gas and other alternate fuel for the entire community would be worth consideration.

Natural gas is, throughout most of Alberta, the cheapest fuel for domestic and light industrial use. The major disadvantage of natural gas is the high capital cost to distribute the fuel to the customer.

As anticipated natural gas offered significant economic advantages over the wood, propane, and diesel fuel that are currently being used as fuel in Chipewyan Lake. The greatest advantage occurs when the majority of the community converts to natural gas. When the use of natural gas declines the cost to distribute the gas increases thus off-setting the cost advantage of the fuel.

Wind and solar energy have failed to attract any significant number of people in Alberta away from natural gas. For this reason, it is expected that these energy sources would not be viable in Chipewyan Lake. Extra insulation in the dwellings could offer some savings in fuel consumed; however, the cost of retrofitting insulation to the predominantly log structures could be rather expensive.

The community of Chipewyan Lake has accepted electric and telephone utilities and natural gas is used in other native communities in Alberta so it could be anticipated that a natural gas utility would receive good acceptance in this situation.

In conclusion, it is apparent that natural gas could offer a significant advantage as a replacement for the fuels currently in use in Chipewyan Lake. The next step that should be taken to provide natural gas to the community would be to obtain a formal declaration of interest from each of the potential customers. This would provide the means to determine the total system demand and thus the cost of distribution service to the community could be provided by a local gas cooperative or by an existing utility company. Either option will have to examine the economics in the context of their respective corporate structures.

OPTIONS ÉNERGÉTIQUES POUR LA COLLECTIVITÉ DE CHIPEWYAN LAKE EN ALBERTA

Résumé

L'Alberta Power Limited a proposé l'utilisation du gaz naturel comme combustible de rechange pour sa centrale électrique située à Chipewyan Lake. La centrale est alimentée actuellement en combustible diesel. Il convient d'examiner l'opportunité, pour toute la collectivité, d'utiliser le gaz naturel et d'autres combustibles de rechange.

Dans l'ensemble de l'Alberta, le gaz naturel est le combustible le moins coûteux pour le secteur domiciliaire et l'industrie légère. Le grand désavantage du gaz naturel réside dans le coût élevé des investissements exigés par la mise en place de l'infrastructure de distribution au consommateur.

Tel qu'il avait été prévu, le gaz naturel offre des avantages sensibles par rapport au bois, au propane et au combustible diesel brûlés actuellement dans la collectivité. On maximalise l'avantage dans l'hypothèse du passage de la majorité de la collectivité au gaz naturel. Une baisse de la consommation relative de gaz naturel entraîne une augmentation du coût relatif de distribution, ce qui réduit l'avantage économique du combustible.

Les options énergie éolienne et énergie solaire n'ont point réussi à trouver un nombre important d'adhérents en Alberta. Pour cette raison, on suppose que ces sources d'énergie ne seraient point rentables pour Chipewyan Lake. Une meilleure isolation thermique des habitations pourrait offrir quelques économies de combustible; le coût d'installation de l'isolation additionnelle aux bâtiments en rondins serait cependant plutôt élevé.

Le hameau de Chipewyan Lake a déjà fait bon accueil à l'électricité et au téléphone, et d'autres collectivités autochtones en Alberta utilisent le gaz naturel, ce qui permet de supposer que le gaz naturel serait bien accueilli dans la situation actuelle.

Il semble donc que le gaz naturel pourrait offrir des avantages sensibles à titre de combustible pouvant remplacer les combustibles utilisés maintenant à Chipewyan Lake. L'étape suivante consisterait à obtenir une déclaration officielle d'intérêt de chacun des consommateurs éventuels, avant de procéder à l'installation de l'infrastructure de distribution de gaz naturel. On pourrait ainsi déterminer la demande totale et le coût de distribution de gaz soit par une coopérative locale de gaz, soit par une société de distribution existante. Chacune aurait à examiner le rentabilité de l'opération dans le contexte de sa propre structure sociétaire.

L'étude a été réalisée par Atcor Engineering pour l'Alberta Power Limited à l'aide d'une subvention accordée par le Programme de démonstration dans les collectivités éloignées d'Énergie, Mines et Ressources Canada.



SECTION 2.0 EXISTING HEATING SYSTEMS

2.1 Introduction

Alberta Power Limited is the major oil user in the community of Chipewyan Lake. Due to the high cost of diesel fuel in the area, the electric rates which are equalized throughout the Province do not cover the cost of the fuel. For this reason, Alberta Power Limited is constantly looking for less expensive fuels for its plant. Any fuel that could offer economic advantages to the Power Plant could offer similar advantages to the rest of the community so Alberta Power Limited commissioned Atcor Engineering to perform an energy study for the community.

2.1 Community Description

The community of Chipewyan Lake is a native settlement in Northern Alberta. Access to the community is by light aircraft or winter road from Fort McMurray. This means that any large supplies of fuel or goods that would have to be shipped by truck could only be delivered in winter.

A visit made to the community and an examination of air photographs indicate a collection of fifty - one dwellings scattered around the southern shore of Chipewyan Lake.

Other than the dwellings in the community, there is a School, a General Store and a small electric Generating Station. Atcor Engineering made a visit to the community during November of 1983. A heat load survey of all of the buildings was completed and other data concerning heating system design was gathered at that time. A meeting was held with Mr. John Horsmier, the operator of the General Store. Mr. Horsmier acted as the spokesperson for the community and liaison with the native council.

2.2 Existing Fuels

The fuels currently in use are wood, propane and diesel fuel.

Wood is the primary heating fuel for the dwellings. In most dwellings wood is used in a wood burning range for cooking and a wood burning heater for space heating. Wood is used to heat the General Store. Wood used for heating is harvested from the forests surrounding the community.

The School uses propane for space heating and domestic hot water heating. The School has sufficient propane storage to permit fuel deliveries to be made once per year via the winter road.

The Power Plant which is owned by Alberta Power Limited is the major oil user. Diesel fuel for the Power Plant is also delivered via the winter road.

The equipment used to burn the various fuels have different efficiencies and this must be reflected in the fuel consumption analysis. Gas, propane and oil burning appliances were assumed to have an efficiency of 60%. Wood burning appliances are assumed to have an efficiency of 45%. Actual figures were available for the Power Plant burning diesel fuel and the efficiency is assumed to be the same using natural gas. For a matter of reference, the calculated efficiency of the Power Plant was 23%.

2.3 Fuel Pricing

A forecast of prices for the three existing fuels used in Chipewyan Lake from 1983 to 2007 is provided in Table 2.0.

The price for diesel fuel is based on the 1983 price paid by Alberta Power Limited of \$0.2812/litre F.O.B. Chipewyan Lake. A heating value of 36.5 megajoules per litre was used to provide a price of \$7.70/gigajoule. An average case world oil price forecast was used to escalate the diesel fuel price to the year 2007.

The price for propane is based on the 1982 price paid by the Northland School Division for propane F.O.B. Chipewyan Lake. The price in 1983 was \$0.22/litre. The heating value of propane is 25.6 megajoules per litre which gives a cost per unit of heat of \$8.59/gigajoule. An index based on the World Price Predictions was used to escalate the cost of propane in a similar manner to diesel fuel.

It was rather difficult to determine a price for wood in Chipewyan Lake as there are no commercial wood suppliers in the community. All of the wood used fuel is cut by the individual home owner. The cost of wood for heating in most areas of Alberta is comprised primarily of labour and equipment costs to cut and deliver the wood and is therefore consistent throughout the Province. An average of prices in Grande Prairie and Fort McMurray was used to give a price of \$80.00/cord for seasoned spruce. Spruce is the most common variety of wood found in the forests near Chipewyan Lake. A heating of 17.9 gigajoules per cord was used to provide a price of \$4.46 per gigajoule in 1983. Because the major contributors to the price of wood are labour and equipment an estimated inflation rate of 5% per year was used to escalate the price of the wood.

2.4 Heat Load Survey

Actual fuel consumption figures were available only for the Power Plant so heating loads for the other buildings had to be estimated.

Environment Canada data was used to estimate a degree day deficiency of 7327.4 degrees celcius days for the community of Chipewyan Lake. By using the degree day deficiency and an assumed average wind speed of 25 kilometres per hour, average heat loads for the various buildings were calculated. The average maximum day was determined to have a 41 degree celcius deficiency. The maximum day was used to calculate peak heating load. The results of these calculations are shown in Table 2.2. The heating loads shown in Table 2.2 are the useful heat output required from the furnace and do not represent burner input.

The dwellings are all of a similar size (66 square metres) with the same type of construction and floor plan. These buildings are fairly new log structures with no insulation in the ceiling or walls. The houses have no basements. The lack of insulation coupled with the rather high infiltration losses of a log structure results in the dwellings having a very high heat load for their size.

The present school consists of two portable structures but the Northland School Division had indicated that the School would be replaced with a permanent structure in 1984. The heating loads for the School shown in Table 2.2 are for the proposed new school which is expected to be approximately 1100 square metres in size and is to have better than average insulation. A new propane storage system will be installed for the new school. The cost of the propane storage will be approximately \$80,000.00.

It has been proposed that the two existing school structures would be donated to the community for use as community buildings. These buildings are referred to as community buildings in Table 2.2 and are each approximately 100 square metres in size.

The General Store is an insulated frame structure that is heated with wood. The store has a floor area of 110 square metres.

The Power Plant has two 62.5 kVA diesel powered generating sets. The generators operate with one unit active and one unit on standby at all times. In 1982 the peak load on the Plant was 47 kW, the total annual energy production was 163,000 kWh, and the annual fuel consumption was 71,850 litres of diesel fuel. The number of electric customers was the same in 1983 as in 1982 so the operation of the Plant would be expected to be the same in 1983. It is not anticipated that electric power demand in the area will change significantly in future years.

Due to the fact that electric power rates in northern communities in Alberta are subsidized through an equalization program the electric power supply agreement that Alberta Power Limited uses in Chipewyan Lake prohibits the use of electricity for space heating.

Table 2.1 EXISTING FUEL PRICES

YEAR	DIESEL \$/GJ	PROPANE \$/GJ	WOOD \$/GJ
1983	7.70	8.59	4.46
1984	8.11	9.05	4.73
1985	8.14	9.08	5.01
1986	9.90	11.04	5.31
1987	11.65	13.00	5.63
1988	13.41	14.96	5.97
1989	15.17	16.92	6.33
1990	16.92	18.88	6.71
1991	18.83	21.00	7.11
1992	20.73	23.12	7.54
1993	22.63	25.25	7.99
1994	24.83	27.70	8.47
1995	27.17	30.31	8.97
1996	29.54	32.96	9.51
1997	32.09	35.80	10.08
1998	34.81	38.83	10.69
1999	37.74	42.10	11.33
2000	40.90	45.63	12.01
2001	44.36	49.48	12.73
2002	48.04	53.60	13.49
2003	52.08	58.10	14.30
2004	56.45	62.97	15.16
2005	61.19	68.26	16.07
2006	66.33	74.00	17.04
2007	71.90	80.21	18.06

Table 2.2

HEAT LOAD SUMMARY

Load Description	Quantity	Peak Load Per Unit	Total Peak Load	Annual Load Per Unit	Total Annual Load	Remarks
Dwellings	51	51 MJ/h	2,601 MJ/H	218 GJ	11,118 GJ	
Store	1	70 MJ/h	70 MJ/H	290 GJ	290 GJ	
Power Plant	1	170 MJ/h	170 MJ/H	587 GJ	587 GJ	
School	1	510 MJ/h	510 MJ/H	1,934 GJ	1,934 GJ	
Community Buildings	2	110 MJ/h	220 MJ/H	387 GJ	774 GJ	2 Old School Bldg.
TOTAL			3,571 MJ/H		14,703 GJ	

NOTE: The heat loads given above represent furnace output not burner input ratings.

SECTION 3.0 NATURAL GAS POTENTIAL

3.1 Natural Gas Sources

The community of Chipewyan Lake is located in the western portion of the Liege gas field. The eastern portion of the field is currently producing and delivering to markets through a pipeline that connects to a major transmission system at a point south of Fort McMurray. The portion of the Liege field nearest to Chipewyan Lake has not indicated gas in sufficient quantity to justify a pipeline at this time. The gas wells in this area are shut in awaiting further developments.

There are two gas wells very close to the community; one is operated by Czar Resources Ltd. and is located in lsd. 7-5-92-22-W4; the other well is operated by Canadian Superior Ltd. and is located in lsd. 10-2-92-22-W4.

Discussions with both the well operators indicated that the wells would produce gas in sufficient quantity to supply the community. Preliminary production tests indicated that the gas would contain minimal amounts of sulphur compounds but would be saturated with water. Given this data it appears that the wells could provide natural gas suitable for domestic use with very little well head conditioning. It appeared, at this point in the study, that natural gas could possibly be a viable alternative energy source for the community.

3.2 Natural Gas Pricing

The price of natural gas for gas utilities in Alberta is protected by the Provincial Government. The protection limits the price of natural gas to a maximum of 65% of the Alberta border price of the gas. Due to the current economic climate for natural gas sales, many purchase contracts are being written for a wellhead price of 65% to as low as 30% of the Alberta border price.

The amount of gas required for a community the size of Chipewyan Lake is rather small so it is assumed that a wellhead price of much less than 65% of Alberta border price would not be attractive to the producers in the area. A wellhead price of 65% of Alberta border price for clean dry gas has been assumed for the purpose of this study.

A forecast for the gas prices to 2007 is provided in Table 3.1. The gas contracts are normally written as a percentage of Alberta border price and change as the border price changes. The Alberta border price forecasts are derived from the Toronto wholesale price which in turn is indexed to the price of oil.

3.3 Gas Distribution System

A distribution piping system to deliver the natural gas to the various buildings in the community would be required. The configuration of a proposed system is shown on the drawing in Appendix D. Polyethylene piping would be used throughout the system operating at a maximum pressure of 500 kPa. It is proposed to use two gas wells as a source in order to provide security of supply in the event that either of the wells develops a problem that requires shutting down production. A 48.3 mm diameter main would interconnect the two wells and a network of smaller diameter branches would feed the buildings. Because of the short distances involved, there is no requirement for high pressure transmission pipelines. The gas conditioning would be provided by the producer but pressure regulation and odorization would have to be provided by the gas utility.

Due to the isolated nature of the community it would be impractical to have a staged growth of the distribution system based on market demand. There would have to be a high percentage of committed customers prior to the project proceeding. In order to provide an analysis of the worst case situation, a design to serve only those customers who have expressed an interest to date was examined. Those customers are the Power Plant, the School, the General Store, and four dwellings for the teachers and store keeper. The two alternatives are referred to throughout the rest of the study

as the "Full Distribution System", and the "Major Loads Only System". The Major Loads Only System would use only one gas well as a source with a propane air system as backup.

The sizing of the distribution piping was done using a computer program a copy of the analysis is provided in Appendix A. The gas flow rates are based on the heat load summary in Table 2.2 and heating value of 37 MJ/cubic metre and a furnace efficiency of 60% and a maximum furnace duty cycle of 80%. The actual 1982 fuel consumption was used to determine the heat input for the Power Plant. The heating demands for the two distribution system alternatives are summarized on Table 3.2.

3.4 Distribution System Costs

Cost estimates were prepared for the two distribution system alternatives. The estimates are based on using a contractor from the Edmonton area and moving equipment and material using the winter road. The construction would take place in the winter. This timing was determined, from discussions with construction firms, to be the most economical and the most desirable.

Detailed cost estimates for the two alternative distribution systems are provided in Appendix B. In summary, the total capital costs are \$414,604 for the full distribution system and \$192,185 for the Major Loads Only System.

Cost estimates for conversion of the various existing heating systems to natural gas are also provided in Appendix B.

3.5 Distribution System Funding

The gas distribution system, envisioned in this study, would qualify for funding under the Alberta Rural Gas Program. A copy of the appropriate portions of the Program Policy Manual are included in Appendix C. Table 3.3 gives a detailed calculation of the various sources of capital. It has been assumed that the large commercial loads would be assessed a connection fee based upon the portion of the system capacity used by their facilities. The large commercial loads in this case are the Power Plant and the School. The

other customers are assumed to contribute a nominal \$500.00 as a commitment to take gas service. These contributions have been included in the conversion cost estimates for the various potential customers.

3.6 Distribution System Cost of Service

Table 3.4 illustrates the calculation of the distribution fee required for the two distribution system cases. The capital investments and financing figures come directly from Table 3.3. The annual system load figures come from Table 3.2. The depreciation is a straight line over 20 years which is common for utility companies. An interest rate of 12.5% per annum was assumed for the portion financed by debt. The operating and maintenance costs are from the cost estimates provided in Appendix B. An inflation rate of 5% per annum was assumed for the operating and maintenance costs over the life of the Project.

The distribution fee given in Table 3.4 is added to the price of the gas to give the burner tip price to the customer.

Table 3.1 GAS PRICES

YEAR	GAS BORDER \$/GJ	GAS UTILITY \$/GJ
1983	2.63	1.71
1984	2.77	1.80
1985	2.78	1.81
1986	3.38	2.20
1987	3.98	2.59
1988	4.58	2.98
1989	5.18	3.37
1990	5.78	3.76
1991	6.43	4.18
1992	7.08	4.60
1993	7.73	5.02
1994	8.48	5.51
1995	9.28	6.03
1996	10.09	6.56
1997	10.96	7.73
1998	11.89	8.38
1999	12.89	9.08
2000	13.97	9.85
2001	15.15	10.67
2002	16.41	11.56
2003	17.79	12.53
2004	19.28	12.53
2005	20.90	13.58
2006	22.66	14.73
2007	24.56	15.96

TABLE 3.2

GAS DISTRIBUTION SYSTEM LOADS

FULL DISTRIBUTION SYSTEM

Load Description	Quantity	Peak Hourly Burner Input		Annual Burner Input	
		Per Unit	Total	Per Unit	Total
Dwellings	51	100 MJ	5,100 MJ	363 GJ	18,513 GJ
Store	1	150 MJ	150 MJ	483 GJ	483 GJ
Power Plant	1	1,000 MJ	1,000 MJ	2,552 GJ	2,552 GJ
School	1	1,100 MJ	1,100 MJ	3,223 GJ	3,223 GJ
Community Buildings	2	200 MJ	400 MJ	645 GJ	1,290 GJ
TOTAL			7,750 MJ		26,061 GJ

TABLE 3.2

GAS DISTRIBUTION SYSTEM LOADS

MAJOR LOAD SYSTEM

Load Description	Quantity	Peak Hourly Burner Input		Annual Burner Input	
		Per Unit	Total	Per Unit	Total
Dwellings	4	100 MJ	400 MJ	363 GJ	1,452 GJ
Store	1	150 MJ	150 MJ	483 GJ	483 GJ
Power Plant	1	1,000 MJ	1,000 MJ	2,552 GJ	2,552 GJ
School	1	1,100 MJ	1,100 MJ	3,223 GJ	3,223 GJ
TOTAL			2,650 MJ		7,110 GJ

TABLE 3.3
SOURCES OF CAPITAL
FULL DISTRIBUTION SYSTEM

A) Government Grants

Total Capital Cost		414,604
Non distribution costs		
- Reg. station	16,000	
- Eng. & Ins. @ 25%	<u>4,000</u>	
		20,000
Net Distribution Capital		<u>394,604</u>
Non-Grantable Consumers		
(Total Cost of Shared Equipment \$355,805)		
School	51,341	
Power Plant	46,750	
General Store	7,726	
Community Buildings	<u>19,204</u>	
		125,021
Grantable Cost		269,583
Grantable cost per customer		5,285
Grant per customer		3,131
Total Grant 51 @ 3,131	159,681	
Reg Station	<u>20,000</u>	
Total Grant		179,681
Customer Sign-up		
51 @ 500	<u>25,500</u>	
		25,500
Borrowing		<u>333,019</u>
TOTAL		664,604

B) Customer Contribution

Domestic 51 @ 500	25,500
General Store	500
Community Buildings 2 @ 500	1,000
School	51,341
Power Plant	46,750
	<u>125,091</u>

C) Debt

Total Requirement	414,604
Less	
- Contributions	125,091
- Grants	<u>179,681</u>
TOTAL DEBT	109,832

TABLE 3.3 "Cont'd"
SOURCES OF CAPITAL
MAJOR LOAD SYSTEM

A) Government Grants

Total Capital Cost		192,185
Non distribution costs		
- Reg. station	8,000	
- Eng. & Ins. @ 25%	<u>2,000</u>	

		10,000
Net Distribution Capital		<u>182,185</u>

Non-Grantable Consumers
(Total Cost of Shared Equipment \$176,725)

School	74,198	
Power Plant	67,528	
General Store	<u>10,843</u>	
		152,569

Grantable Cost 24,156

Grantable cost per customer		6,039
Grant per customer		3,810
Total Grant 51 @ 3,810	15,240	
Reg Station	<u>10,000</u>	
Total Grant		25,240

B) Customer Contribution

Domestic 4 @ 500	2,000	
General Store 1 @ 500	500	
Community Buildings 2 @ 500	1,000	
School	74,198	
Power Plant	67,528	
	<u>145,226</u>	

C) Debt

Total Requirement	192,185	
Less		
- Contributions	145,226	
- Grants	<u>25,240</u>	

TOTAL DEBT 21,719

Table 3.4 GAS DISTRIBUTION FEE FULL SYSTEM

YEAR	LOAD GJ	CAPITAL \$(000)	DEPREC \$(000)	DEBT \$(000)	INTEREST \$(000)	O & M \$(000)	TOTAL EXP. \$(000)	DIST FEE \$/GJ
1983		414.60		109.80		30.80		
1984	26,061.0		20.73		13.73	32.65	67.10	2.57
1985	26,061.0		20.73		13.73	34.61	69.06	2.65
1986	26,061.0		20.73		13.73	36.68	71.14	2.73
1987	26,061.0		20.73		13.73	38.88	73.34	2.81
1988	26,061.0		20.73		13.73	41.22	75.67	2.90
1989	26,061.0		20.73		13.73	43.69	78.15	3.00
1990	26,061.0		20.73		13.73	46.31	80.77	3.10
1991	26,061.0		20.73		13.73	49.09	83.55	3.21
1992	26,061.0		20.73		13.73	52.04	86.49	3.32
1993	26,061.0		20.73		13.73	55.16	89.61	3.44
1994	26,061.0		20.73		13.73	58.47	92.92	3.57
1995	26,061.0		20.73		13.73	61.98	96.43	3.70
1996	26,061.0		20.73		13.73	65.69	100.15	3.84
1997	26,061.0		20.73		13.73	69.64	104.09	3.99
1998	26,061.0		20.73		13.73	73.81	108.27	4.15
1999	26,061.0		20.73		13.73	78.24	112.70	4.32
2000	26,061.0		20.73		13.73	82.94	117.39	4.50
2001	26,061.0		20.73		13.73	87.91	122.37	4.70
2002	26,061.0		20.73		13.73	93.19	127.64	4.90
2003	26,061.0		20.73		13.73	98.78	133.23	5.11
2004	26,061.0		0.00		13.73	104.71	118.43	4.54
2005	26,061.0		0.00		13.73	110.99	124.71	4.79
2006	26,061.0		0.00		13.73	117.65	131.37	5.04
2007	26,061.0		0.00		13.73	124.71	138.43	5.31

Table 3.4 GAS DISTRIBUTION FEE MAJOR LOADS

YEAR	LOAD GJ	CAPITAL \$(000)	DEPREC \$(000)	DEBT \$(000)	INTEREST \$(000)	O & M \$(000)	TOTAL EXP. \$(000)	DIST FEE \$/GJ
1983		192.20		21.70		26.30		
1984	7,110.00		9.61		2.71	27.88	40.20	5.65
1985	7,110.00		9.61		2.71	29.55	41.87	5.89
1986	7,110.00		9.61		2.71	31.32	43.65	6.14
1987	7,110.00		9.61		2.71	33.20	45.53	6.40
1988	7,110.00		9.61		2.71	35.20	47.52	6.68
1989	7,110.00		9.61		2.71	37.31	49.63	6.98
1990	7,110.00		9.61		2.71	39.55	51.87	7.30
1991	7,110.00		9.61		2.71	41.92	54.24	7.63
1992	7,110.00		9.61		2.71	44.43	56.76	7.98
1993	7,110.00		9.61		2.71	47.10	59.42	8.36
1994	7,110.00		9.61		2.71	49.93	62.25	8.75
1995	7,110.00		9.61		2.71	52.92	65.24	9.18
1996	7,110.00		9.61		2.71	56.10	68.42	9.62
1997	7,110.00		9.61		2.71	59.46	71.78	10.10
1998	7,110.00		9.61		2.71	63.03	75.35	10.60
1999	7,110.00		9.61		2.71	66.81	79.13	11.13
2000	7,110.00		9.61		2.71	70.82	83.14	11.69
2001	7,110.00		9.61		2.71	75.07	87.39	12.29
2002	7,110.00		9.61		2.71	79.57	91.90	12.92
2003	7,110.00		9.61		2.71	84.35	96.67	13.60
2004	7,110.00		0.00		2.71	89.41	92.12	12.96
2005	7,110.00		0.00		2.71	94.77	97.49	13.71
2006	7,110.00		0.00		2.71	100.46	103.17	14.51
2007	7,110.00		0.00		2.71	106.49	109.20	15.36

SECTION 4.0 ECONOMIC ANALYSIS

4.1 Preliminary Analysis

By examining the prices of existing fuels given in Table 2.1 it can be seen that propane is the most expensive fuel and therefore would not be an economical replacement for diesel fuel. Wood may appear to have a price advantage over diesel fuel; however, the major diesel fuel user is the Power Plant and it would not be practical to produce commercial power using wood. The analysis is thus reduced to examining natural gas as an alternative fuel for each of the existing fuels as they are currently being used.

4.2 Method of Analysis

The method used to analyse natural gas as an alternative fuel was to determine a discounted net benefit for each of the existing fuels. The analysis is illustrated in Tables 4.1 through 4.6 for both of the distribution system configurations. A discount rate of 5% was used to calculate the net benefit in constant 1983 dollars. The discount rate is equal to the assumed inflation rate. This provides a discounted benefit that does not reflect any risk or the cost of money to the customer for conversion. The assessment of risk and the cost of money would have to be done by the individual customer depending on their own criteria.

4.3 Discussion of Results

Tables 4.1, 4.2 and 4.3 indicate a positive discounted net benefit for the dwellings, school and power plant using natural gas in place of their existing fuel. The burner tip gas price is based on the full distribution system configuration. The conversion cost for a dwelling is \$2,950.00 which would be paid out in approximately 4.6 years based on constant dollars. The Power Plant with a conversion cost of \$96,750.00 would achieve a discounted payout in approximately 7.6 years. The School would achieve a discounted payout on its conversion costs of \$52,341.00 in approximately 3.5 years.

These short payout periods along with a substantial discounted net benefit at the end of a projected twenty five year life suggest that natural gas service serving the full community has economic advantages.

Table 4.4 gives the benefit for a dwelling if the distribution system is reduced to serve the major loads only. The net benefit, in this case, is negative which indicates that there is no financial incentive for the homeowner to convert from wood to natural gas. Tables 4.5 and 4.6; however, indicate that there would still be a substantial net benefit for the Power Plant and School. The \$117,528 conversion of the Power Plant would achieve payout in approximately 13.1 years which would indicate a rather marginal economic benefit. The School would achieve payout of its conversion costs in approximately 7.3 years. These economics for the School are still quite favourable.

4.4 Factors Affecting Economic

It should be noted that the new school was planning to invest \$80,000.00 on a new propane storage and delivery system. If this cost could be avoided, by a timely conversion to natural gas, the economic advantages of natural gas would be much improved. There could be some improvement to the economics for the power plant if the conversion to natural gas were to become part of a scheduled plant upgrade thus offsetting some of the costs.

There have been proposals to construct an all weather highway to the community. If such a road were built it would reduce the cost of shipping diesel fuel and propane to the area but it would also significantly reduce the cost to construct a natural gas distribution system. The net effect on the comparison of the fuels would be insignificant.

As long as the community remains isolated, there could be significant reductions in conversion costs if they were all to be done at once rather than on a one at a time basis as shown in the cost estimates.

The use of local labour for the non skilled work for the construction of the gas distribution system could reduce some of the construction costs by reducing the subsistence costs.

Table 4.1 BENEFIT FOR DWELLING FULL SYSTEM

YEAR	GAS PRICE \$/GJ	GAS 60% EFF GJ/YR	GAS COST \$/YR	WOOD PRICE \$/GJ	WOOD 45% EFF GJ/YR	WOOD COST \$/YR	NET BENEFIT \$/YR	DISC BENEFIT \$/YR
1983								
1984	4.38	363.00	1588.25	4.73	484.00	2288.16	699.91	657.91
1985	4.46	363.00	1617.89	5.01	484.00	2425.45	807.55	713.55
1986	4.93	363.00	1788.39	5.31	484.00	2570.97	782.59	650.01
1987	5.40	363.00	1960.61	5.63	484.00	2725.23	764.62	596.98
1988	5.88	363.00	2134.68	5.97	484.00	2888.75	754.07	553.41
1989	6.27	363.00	2310.70	6.33	484.00	3062.07	751.37	518.35
1990	6.86	363.00	2488.78	6.71	484.00	3245.00	757.02	490.91
1991	7.39	363.00	2680.85	7.11	484.00	3440.54	759.69	463.08
1992	7.92	363.00	2875.25	7.54	484.00	3646.98	771.83	442.20
1993	8.46	363.00	3072.10	7.99	484.00	3865.80	793.69	427.50
1994	9.08	363.00	3295.16	8.47	484.00	4097.74	802.58	406.35
1995	9.73	363.00	3532.78	8.97	484.00	4343.61	810.82	385.89
1996	10.40	363.00	3775.70	9.51	484.00	4604.22	828.52	370.65
1997	11.72	363.00	4255.31	10.08	484.00	4880.48	625.17	262.90
1998	12.53	363.00	4549.46	10.69	484.00	5173.31	623.85	246.60
1999	13.40	363.00	4865.97	11.33	484.00	5483.70	617.73	229.53
2000	14.35	363.00	5209.78	12.01	484.00	5812.73	602.94	210.60
2001	15.36	363.00	5576.40	12.73	484.00	6161.49	585.10	192.10
2002	16.46	363.00	5975.48	13.49	484.00	6531.18	555.70	171.50
2003	17.64	363.00	6404.92	14.30	484.00	6923.05	518.13	150.31
2004	17.08	363.00	6198.73	15.16	484.00	7338.43	1139.70	310.80
2005	18.37	363.00	6668.36	16.07	484.00	7778.74	1110.38	284.63
2006	19.77	363.00	7175.35	17.04	484.00	8245.46	1070.12	257.85
2007	21.27	363.00	7722.69	18.06	484.00	8740.19	1017.50	230.46
TOTAL		8712.00	97723.60		11616.00	116274.00	18550.50	9224.07

Table 4.2 BENEFIT FOR POWER PLANT FULL SYSTEM

YEAR	GAS PRICE \$/GJ	GAS INPUT GJ/YR	GAS COST \$/YR	DIESEL PRICE \$/GJ	DIESEL INPUT GJ/YR	DIESEL COST \$/YR	NET BENEFIT \$/YR	DISC BENEFIT \$/YR
1983				7.70				
1984	4.38	2552.00	11165.90	8.11	2552.00	20696.40	9530.55	8958.72
1985	4.46	2552.00	11374.30	8.14	2552.00	20771.10	9396.86	8303.06
1986	4.93	2552.00	12572.90	9.90	2552.00	25254.10	12681.20	10532.80
1987	5.40	2552.00	13783.70	11.65	2552.00	29737.10	15953.40	12455.60
1988	5.88	2552.00	15007.50	13.41	2552.00	34220.10	19212.60	14100.20
1989	6.37	2552.00	16244.90	15.17	2552.00	38703.10	22458.20	15493.20
1990	6.86	2552.00	17496.90	16.92	2552.00	43186.10	25689.20	16658.90
1991	7.39	2552.00	18847.20	18.83	2552.00	48042.60	29195.40	17796.60
1992	7.92	2552.00	20213.90	20.73	2552.00	52899.20	32685.30	18728.50
1993	8.46	2552.00	21597.80	22.63	2552.00	57755.70	36157.90	19475.20
1994	9.08	2552.00	23166.00	24.83	2552.00	63359.50	40193.50	20349.20
1995	9.73	2552.00	24836.50	27.17	2552.00	69336.80	44500.20	21178.60
1996	10.40	2552.00	26544.30	29.54	2552.00	75388.80	48844.50	21851.30
1997	11.72	2552.00	29916.10	32.09	2552.00	81889.10	51973.00	21855.80
1998	12.53	2552.00	31984.10	34.81	2552.00	88837.70	56853.70	22473.80
1999	13.40	2552.00	34209.30	37.74	2552.00	96309.40	62100.10	23074.80
2000	14.35	2552.00	36626.40	40.90	2552.00	104379.00	67752.40	23664.50
2001	15.36	2552.00	39203.70	44.36	2552.00	113195.00	73991.50	24293.10
2002	16.46	2552.00	42009.40	48.04	2552.00	122610.00	80600.10	24875.10
2003	17.64	2552.00	45028.60	52.08	2552.00	132920.00	87891.80	25498.00
2004	16.08	2552.00	43579.00	56.45	2552.00	144053.00	100474.00	27399.30
2005	18.37	2552.00	46880.60	61.19	2552.00	156154.00	109273.00	28010.80
2006	19.77	2552.00	50444.90	66.33	2552.00	169270.00	118826.00	28631.90
2007	21.27	2552.00	54292.80	71.90	2552.00	183489.00	129196.00	29263.00
TOTAL		61248.00	687027.00		61248.00	1972457.00	1285431.00	484923.00

Table 4.3 BENEFIT FOR SCHOOL FULL SYSTEM

YEAR	BURNER PRICE \$/GJ	GAS 60% EFF GJ/YR	GAS COST \$/YR	PROPANE PRICE \$/GJ	PROPANE 60% EFF GJ/YR	PROPANE COST \$/YR	NET BENEFIT \$/YR	DISC BENEFIT \$/YR
1983				8.59				
1984	4.38	3223.00	14101.70	9.05	3223.00	29159.30	15057.60	14154.10
1985	4.46	3223.00	14364.90	9.08	3223.00	29264.60	14899.70	13165.30
1986	4.93	3223.00	15878.70	11.04	3223.00	35580.70	19702.00	16364.20
1987	5.40	3223.00	17407.90	13.00	3223.00	41896.80	24488.90	19119.70
1988	5.88	3223.00	18953.40	14.96	3223.00	48212.90	29259.50	21473.70
1989	6.37	3223.00	20516.20	16.92	3223.00	54529.00	34012.80	23464.40
1990	6.86	3223.00	22097.40	18.88	3223.00	60845.10	38747.70	25127.00
1991	7.39	3223.00	23802.70	21.00	3223.00	67687.50	43884.80	26750.80
1992	7.92	3223.00	25528.70	23.12	3223.00	74530.00	49001.30	28077.50
1993	8.46	3223.00	27276.50	25.25	3223.00	81372.40	54095.90	29136.90
1994	9.08	3323.00	29257.00	27.70	3223.00	89267.50	60010.50	30383.20
1995	9.73	3223.00	31366.80	30.31	3223.00	97689.00	66322.20	31564.10
1996	10.40	3223.00	33523.60	32.96	3223.00	106216.00	72692.10	32519.90
1997	11.72	3223.00	37782.00	35.00	3223.00	115374.00	77592.10	32629.30
1998	12.53	3223.00	40393.70	38.83	3223.00	125164.00	84770.40	33509.00
1999	13.40	3223.00	43203.90	42.10	3223.00	135691.00	92486.90	34365.80
2000	14.35	3223.00	46256.60	45.63	3223.00	147060.00	100803.00	35208.60
2001	15.36	3223.00	49511.60	49.48	3223.00	159482.00	109970.00	36105.60
2002	16.46	3223.00	53055.00	53.60	3223.00	172745.00	119690.00	36939.30
2003	17.64	3223.00	56868.00	58.10	3223.00	187272.00	130404.00	27831.10
2004	17.08	3223.00	55037.20	62.97	3223.00	202957.00	147920.00	40337.80
2005	18.37	3223.00	59207.00	68.26	3223.00	220006.00	160799.00	41218.80
2006	19.77	3223.00	63708.40	74.00	3223.00	238486.00	174778.00	42114.10
2007	21.27	3223.00	68568.10	80.21	3223.00	258519.00	189951.00	43023.90
TOTAL		77352.00	867667.00		77352.00	2779007.00	1911340.00	724584.00

Table 4.4 BENEFIT FOR DWELLING MAJOR LOADS

YEAR	GAS PRICE \$/GJ	GAS 60% EFF GJ/YR	GAS COST \$/YR	WOOD PRICE \$/GJ	WOOD 45% EFF GJ/YR	WOOD COST \$/YR	NET BENEFIT \$/YR	DISC BENEFIT \$/YR
1983								
1984	7.45	363.00	2706.01	4.73	484.00	2288.16	-417.85	-392.78
1985	7.70	363.00	2793.77	5.01	484.00	2425.45	-368.32	-325.45
1986	8.34	363.00	3025.86	5.31	484.00	2570.97	-454.89	-377.82
1987	8.99	363.00	3263.39	5.63	484.00	2725.23	-538.15	-420.16
1988	9.66	363.00	3506.67	5.97	484.00	2888.75	-617.92	-453.49
1989	10.35	363.00	3756.05	6.33	484.00	3062.07	-693.98	-478.75
1990	11.05	363.00	4011.90	6.71	484.00	3245.80	-766.11	-496.80
1991	11.81	363.00	4286.41	7.11	484.00	3440.54	-845.87	-515.61
1992	12.58	363.00	4568.18	7.54	484.00	3646.98	-921.21	-527.85
1993	13.38	363.00	4857.66	7.99	484.00	3865.80	-991.87	-534.24
1994	14.27	363.00	5178.91	8.47	484.00	4097.74	-1081.20	-547.39
1995	15.21	363.00	5520.60	8.97	484.00	4343.61	-1177.00	-560.16
1996	16.18	363.00	5873.83	9.51	484.00	4604.22	-1269.60	-567.98
1997	17.82	363.00	6470.38	10.08	484.00	4880.48	-1589.90	-668.59
1998	18.98	363.00	6888.48	10.69	484.00	5173.31	-1715.20	-677.99
1999	20.21	363.00	7336.38	11.33	484.00	5483.70	-1852.70	-688.41
2000	21.54	363.00	7819.47	12.01	484.00	5812.73	-2006.70	-700.91
2001	22.96	363.00	8333.71	12.73	484.00	6161.49	-2172.20	-713.19
2002	24.49	363.00	8889.28	13.49	484.00	6531.18	-2358.10	-727.76
2003	26.13	363.00	9484.60	14.30	484.00	6923.05	-2561.50	-743.12
2004	25.49	363.00	9252.34	15.16	484.00	7338.43	-1913.90	-521.92
2005	27.30	363.00	9908.35	16.07	484.00	7778.74	-2129.60	-545.90
2006	29.24	363.00	10612.90	17.04	484.00	8245.46	-2367.40	-570.45
2007	31.32	363.00	11369.60	18.06	484.00	8740.19	-2629.50	-595.57
TOTAL		8712.00	149715.00		11616.00	116274.00	-33441.00	-13352.00

Table 4.5 BENEFIT FOR POWER PLANT MAJOR LOADS

YEAR	GAS PRICE \$/GJ	GAS INPUT GJ/YR	GAS COST \$/YR	DIESEL PRICE \$/GJ	DIESEL INPUT GJ/YR	DIESEL COST \$/YR	NET BENEFIT \$/YR	DISC BENEFIT \$/YR
1983				7.70				
1984	7.45	2552.00	19024.10	8.11	2552.00	20696.40	1672.34	1572.00
1985	7.70	2552.00	19641.00	8.14	2552.00	20771.10	1311.10	998.55
1986	8.34	2552.00	21272.70	9.90	2552.00	25254.10	3981.40	3306.88
1987	8.99	2552.00	22942.60	11.65	2552.00	29737.10	6794.51	5304.81
1988	9.66	2552.00	24652.90	13.41	2552.00	34220.10	9567.16	7021.38
1989	10.35	2552.00	26406.20	15.17	2552.00	38703.10	12296.90	8483.26
1990	11.05	2552.00	28204.90	16.92	2552.00	43186.10	14981.20	9714.94
1991	11.81	2552.00	30134.80	18.83	2552.00	48042.60	17907.90	10916.10
1992	12.58	2552.00	32115.70	20.73	2552.00	52899.20	20783.50	11908.80
1993	13.38	2552.00	34150.90	22.63	2552.00	57755.70	23604.90	12713.90
1994	14.27	2552.00	36409.30	24.83	2552.00	63359.50	26950.20	13644.80
1995	15.21	2552.00	38811.50	27.17	2552.00	69336.80	30525.30	14527.60
1996	16.18	2552.00	41294.80	29.54	2552.00	75388.80	34094.00	15252.50
1997	17.82	2552.00	45488.70	32.09	2552.00	81889.10	36400.40	15307.20
1998	18.98	2552.00	48428.10	34.81	2552.00	88837.70	40409.60	15973.60
1999	20.21	2552.00	51577.00	37.74	2552.00	96309.40	44732.40	16621.40
2000	21.54	2552.00	54973.20	40.90	2552.00	104379.00	49405.50	17256.40
2001	22.96	2552.00	58588.50	44.36	2552.00	113195.00	54606.80	17928.70
2002	24.49	2552.00	62494.30	48.04	2552.00	122610.00	60115.20	18553.00
2003	26.13	2552.00	66679.60	52.08	2552.00	132920.00	66240.80	19216.90
2004	25.49	2552.00	65046.80	56.45	2552.00	144053.00	79006.40	21545.00
2005	27.30	2552.00	69658.70	61.19	2552.00	156154.00	86494.90	22171.90
2006	29.24	2552.00	74611.90	66.33	2552.00	169270.00	94658.60	22808.70
2007	31.32	2552.00	79932.10	71.90	2552.00	183489.00	103357.00	23455.70
TOTAL		61248.00	1052540.00		61248.00	1972457.00	919917.00	326204.00

Table 4.6 BENEFIT FOR SCHOOL MAJOR LOADS

YEAR	BURNER PRICE \$/GJ	GAS 60% EFF GJ/YR	GAS COST \$/YR	PROPANE PRICE \$/GJ	PROPANE 60% EFF GJ/YR	PROPANE COST \$/YR	NET BENEFIT \$/YR	DISC BENEFIT \$/YR
1983				8.59				
1984	7.45	3223.00	24026.10	9.05	3223.00	29159.30	5133.22	4825.23
1985	7.70	3223.00	24805.30	9.08	3223.00	29264.60	4459.30	3940.24
1986	8.34	3223.00	26866.00	11.04	3223.00	35580.70	8714.70	7238.29
1987	8.99	3223.00	28974.90	13.00	3223.00	41886.80	12921.90	10088.70
1988	9.66	3223.00	31135.00	14.96	3223.00	48212.90	17077.90	12533.60
1989	10.35	3223.00	33349.20	16.92	3223.00	54529.00	21179.80	14611.30
1990	11.05	3223.00	35620.80	18.88	3223.00	60845.10	25224.30	16357.40
1991	11.81	3223.00	38058.10	21.00	3223.00	67687.50	29629.40	18061.20
1992	12.58	3223.00	40559.90	23.12	3223.00	74530.00	33970.00	19464.70
1993	13.38	3223.00	43130.20	25.25	3223.00	81372.40	38252.20	20597.90
1994	14.27	3223.00	45982.40	27.70	3223.00	89267.50	43285.10	21915.20
1995	15.21	3223.00	49016.20	30.31	3223.00	97689.00	48672.80	23164.40
1996	16.18	3223.00	52152.50	32.96	3223.00	106216.00	54063.20	24186.00
1997	17.82	3223.00	57449.10	35.80	3223.00	115374.00	57924.90	24358.80
1998	18.98	3223.00	61161.40	38.83	3223.00	125164.00	64002.70	25299.70
1999	20.21	3223.00	65138.20	42.10	3223.00	135691.00	70552.70	26215.60
2000	21.54	3223.00	69427.40	45.63	3223.00	147060.00	77632.50	27115.50
2001	22.96	3223.00	73993.20	49.48	3223.00	159482.00	85488.30	28067.80
2002	24.49	3223.00	78926.00	53.60	3223.00	172745.00	93819.30	28954.90
2003	26.13	3223.00	84211.70	58.10	3223.00	187272.00	103061.00	29898.50
2004	25.49	3223.00	82149.60	62.97	3223.00	202957.00	120808.00	32944.30
2005	27.30	3223.00	87974.10	68.26	3223.00	220006.00	132032.00	33844.70
2006	29.24	3223.00	94229.60	74.00	3223.00	238486.00	144257.00	34759.70
2007	31.32	3223.00	100949.00	80.21	3223.00	258519.00	157570.00	35689.70
TOTAL		77352.00	1329286.00		77352.00	2779007.00	1449721.00	524133.00

SECTION 5.0 ENERGY CONSERVATION

It would be unlikely that conversion to natural gas would result in any energy conservation. In fact the convenience of natural gas over wood could lead to an increase of energy use. The proposed new school will have a high standard of insulation and it would be unlikely to be upgraded further.

The efficiency of the Power Plant cannot be practically increased by a significant amount. There is; however, the possibility of recovering some of the wasted heat from the Power Plant for use in space heating. It has been estimated that there could be 810 gigajoules of usable waste heat per year available from the Power Plant which could heat three average dwellings. If this heat is evaluated at the cost of wood heating this represents a value of \$3,758.40 per year. The cost of recovering and distributing the heat to the closest dwellings would be in the order of \$50,000.00 to \$100,000.00 which would mean a payout in excess of twenty years. For this reason, waste heat recovery was not considered a viable alternative. It is possible that when the two community buildings are relocated off of the school site they could be located close to the Power Plant and waste heat could be used to heat them on an experimental basis using a simplified distribution system.

Due to the northerly location of the community, solar heat would not be practical.

It is not expected that any minor conservation schemes would seriously affect the economics of converting to natural gas.

SECTION 6.0 SOCIO-ECONOMIC CONSIDERATIONS

6.1 Employment Opportunities

There could be some work available to the community in the installation of a gas distribution system. The operation of the equipment to trench and join the plastic pipe is rather specialized and it is doubtful if the community could be involved in these activities. There is; however, considerable non specialized work required to clear brush from the pipeline route that could involve the community. There may also be some additional work available in the board and lodging of the construction crews.

Operation of the gas distribution system will require one trained person. Initially this will require an experienced individual but over a period of a year local personnel could be trained to carry out most of the operation and maintenance of the system.

6.2 Social Impact

Chipewyan Lake is a very isolated community. The major source of income for the residents is fur trapping which takes place primarily in the winter.

Electricity and telephone have been introduced to the community only in the last few years. These utilities have been accepted rather well in the community. Almost all of the occupied dwellings have electric service and approximately 20% have telephone. The use of these utilities appear to have had no detrimental effects on the community. There has been an improvement to the quality of life provided by the convenience of these utilities.

Based on the acceptance of the community to electricity and telephone it should be safe to assume that natural gas service would receive a similar acceptance. At present, when the families leave for several weeks to service their trap lines the dwellings are left to freeze. Natural gas service would allow the residents to keep their dwellings heated while they were absent. This would permit the storage of perishable products in the houses during the winter. Natural gas can also offer significant advantages as a cooking fuel.

CHIEPEWYAN LAKES
DESIGN CHECK
DEC 13, 1983
GENERAL FLOW EQN.

APPENDIX A - DISTRIBUTION SYSTEM DESIGN CALCULATIONS

P1 AND P2 = 80 20
ATMOSPHERIC PRESS. = 13.5
SPEC. GRAV. = .61

INLET PRESS SQD E ALLOW TOTAL LENGTH E DRP ALL/100
8742.2 7620.0 23120 33.0

ID	MC FH	DROP CFH	FEET	E-DRP	ACC E-DRP	P2
1.552	7.550	100	4600	2242.3	2242.3	67.1
REYNOLDS NO. = 137601.1						
FRICTION FACTOR = 4.336499E-03						
SECH DRP/100 = 48.74599						
1.552	7.450	300	1060	504.3	2746.6	63.9
REYNOLDS NO. = 135778.6						
FRICTION FACTOR = 4.347023E-03						
SECH DRP/100 = 47.57841						
1.552	7.150	200	530	234.0	2980.7	62.4
REYNOLDS NO. = 130311						
FRICTION FACTOR = 4.379623E-03						
SECH DRP/100 = 44.15242						
1.552	6.950	800	5800	2432.1	5412.7	44.2
REYNOLDS NO. = 126665.9						
FRICTION FACTOR = 4.402276E-03						
SECH DRP/100 = 41.93268						
1.552	6.150	100	1590	533.8	5946.6	39.4
REYNOLDS NO. = 112085.7						
FRICTION FACTOR = 4.501246E-03						
SECH DRP/100 = 33.57288						
1.552	6.050	500	530	172.7	6119.3	37.7
REYNOLDS NO. = 110263.1						
FRICTION FACTOR = 4.514676E-03						
SECH DRP/100 = 32.58688						
1.552	5.550	200	530	147.6	6266.9	36.3
REYNOLDS NO. = 101150.4						
FRICTION FACTOR = 4.586037E-03						
SECH DRP/100 = 27.85667						
1.552	5.350	400	530	133.7	6400.6	34.9
REYNOLDS NO. = 97505.37						
FRICTION FACTOR = 4.470639E-03						
SECH DRP/100 = 25.2338						
1.552	4.950	1000	1060	233.5	6634.1	32.4
REYNOLDS NO. = 90215.25						
FRICTION FACTOR = 4.558343E-03						
SECH DRP/100 = 22.02536						
1.552	3.950	600	530	78.6	6712.8	31.5
REYNOLDS NO. = 71989.94						
FRICTION FACTOR = 4.822910E-03						
SECH DRP/100 = 14.83915						
1.552	3.350	100	1590	176.8	6889.6	29.5
REYNOLDS NO. = 61054.77						
FRICTION FACTOR = 5.025703E-03						
SECH DRP/100 = 11.12223						
1.552	3.250	2450	1060	111.8	7001.4	28.2
REYNOLDS NO. = 59232.28						
FRICTION FACTOR = 5.063929E-03						
SECH DRP/100 = 10.54775						
1.552	0.800	200	1060	9.6	7011.0	28.1
REYNOLDS NO. = 14580.25						
FRICTION FACTOR = 7.189289E-03						
SECH DRP/100 = .9073429						
1.552	0.600	300	1590	8.7	7019.7	28.0
REYNOLDS NO. = 10935.19						
FRICTION FACTOR = 7.725392E-03						
SECH DRP/100 = .5484394						
1.552	0.300	300	1060	1.7	7021.5	28.0
REYNOLDS NO. = 5467.594						
FRICTION FACTOR = 9.187087E-03						
SECH DRP/100 = .1630518						

Q INCR. = .2999998

CALCULATIONS COMPLETE
0.0 SECS

APPENDIX B - COST ESTIMATES

Table B-1

Natural Gas Distribution

Full Distribution System

Construction Cost Estimate

PROJECT: Chipewyan Lake

ESTIMATED BY: S.R. Andriuk

Item	Unit Prices		Estimated Quantity	Cost Estimate		
	Labour	Material		Labour	Material	Total
1.0 Plastic Urban Pipeline (by trenching)						
26.7 mm	\$3.28/m	\$0.80	3500	\$11,480	\$2,800	\$14,280
33.4 mm	3.40/m	1.20	600	2,040	720	2,760
48.3 mm	6.80/m	3.00	8200	55,760	24,600	80,360
1.1 Plastic Fittings						
Tracer Wire		0.17	12300		2,091	2,091
2.0 Cable Crossing						
each	200.00	—	20	4,000		4,000
3.0 Major Creek Crossing						
each	1200.00	—	1	1,200		1,200
4.0 Brushing						
lin metre	700.00	—	12300	86,100		86,100
5.0 Frost Thawing						
lin metre	2.00	3.11	12300	24,600	38,253	62,853
6.0 Urban Yard Service (incl. 22 m 15.9 mm PE)						
each	200.00	140.00	56	11,200	7,840	19,040
<u>Meter Set</u>						
each	100.00	400.00	56	5,600	22,400	28,000
<u>Other Costs (Specify)</u>						
Reg-Meter Combination (2)						16,000
Construction Camp (6 Man)		500.00	30			15,000

	<u>Cost Estimate</u>		
	<u>Labour</u>	<u>Material</u>	<u>Total</u>
SUBTOTAL PIPELINE COSTS	\$ 69,760	\$28,120	\$ 97,400
SUBTOTAL CROSSING COSTS	132,700	70,584	203,284
SUBTOTAL OTHER COSTS			31,000

TOTAL ESTIMATED COST OF CONSTRUCTION		\$331,684
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Overhead Costs

Engineering and Project Management - 10%	33,168
Inspection, Supervision, Staking and As-Builts - 15%	49,752
Interest during Construction (12% per a for 3 months)	--

TOTAL ESTIMATED CAPITAL COST FOR PROJECT	\$414,604
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Table B-2
Natural Gas Distribution
Major Loads Only
Construction Cost Estimate

PROJECT: Chipewyan Lake

ESTIMATED BY: S.R. Andriuk

Item	Unit Prices		Estimated Quantity	Cost Estimate		
	Labour	Material		Labour	Material	Total
1.0 <u>Plastic Urban Pipeline</u> (by trenching)						
26.7 mm	\$3.28/m	\$0.80	980	\$ 3,214	\$784	\$3,998
33.4 mm	3.40/m	1.20	5130	17,442	6,156	23,598
2.0 <u>Cable Crossing</u>						
each	200.00		10	2,000		2,000
3.0 <u>Major Creek Crossing</u>						
each	1200.00	—	1	1,200		1,200
4.0 <u>Brushing</u>						
lin metre	7.00	—	6110	42,770		42,770
5.0 <u>Frost Thawing</u>						
lin metre	2.00	3.11	6110	12,220	19,002	31,222
6.0 <u>Urban Yard Service</u> (incl. 22 m 15.9 mm PE)						
each	200.00	140.00	7	1,400	560	1,960
<u>Meter Set</u>						
each	100.00	400.00	7	700	2,800	3,500
<u>Other Costs</u> (Specify)						
Reg-Meter Combination (2)						8,000
Dehydration Unit						
Construction Camp (6 Man)		500.00	21			10,500
Dual Fuel Back-up (Propane)						25,000

	Cost Estimate		
	<u>Labour</u>	<u>Material</u>	<u>Total</u>
SUBTOTAL PIPELINE COSTS			\$ 27,596
SUBTOTAL CROSSING COSTS			82,652
SUBTOTAL OTHER COSTS			143,500

TOTAL ESTIMATED COST OF CONSTRUCTION			\$153,748
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Overhead Costs

Engineering and Project Management - 10%			15,375
Inspection, Supervision, Staking and As-Builts - 15%			23,062
Interest during Construction (12% per a for 3 months)			--

TOTAL ESTIMATED CAPITAL COST FOR PROJECT			\$192,185
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Table B-3
SUBSISTENCE AND FROST THAWING
Unit Cost Derivation

CONSTRUCTION CAMP (6 Man)

Move-In 2 Unit Camp

- Edmonton Fort McMurray 480 km @ \$1.63	\$ 790.00
- Fort McMurray to Chipewyan Lake 10 Hr. @ \$52.00/hr. x 2 Units	1,040.00
2 Unit Camp Rental \$100.00/Day for 30 Days	3,000.00
Cook @ \$140.00/Day for 30 Days	4,200.00
Food Charge @ \$18.00/Man/Day	3,240.00
Restock Food (Mileage charge @ 60¢/km) 1,400 km	840.00
Move-Out 2 Unit Camp (same as move-in)	1,830.00

\$14,940.00

TOTAL

\$15,000.00

Unit cost $15,000 - 30 = \$500/\text{day}$ for 6 man camp.

NOTE: This portion of the cost estimate was based on values provided by Edmonton based camp catering services.

FROST THAWING

COAL

Cost of coal at mine is \$14.30 per metric ton. One metric tone of coal is required to thaw about 33.5 metres of pipeline trench.

$$12,300 \text{ M of Trench} \times \frac{1 \text{ Tonne}}{33.5\text{m}} = 367.2 \text{ Tonne}$$

use 370 Tonne

370.0 Tonne @ \$14.30

\$ 5,291.00

Cost of Transport from Edmonton
\$68.75/Tonne x 370 Tonne

25,437.50

STRAW

Cost of Straw Sales is about \$0.75 per bale.
10 Bales are required per 30.5 metres of trench.

$$12,300\text{m of Trench} \times \frac{10 \text{ Bales}}{30.5\text{m}} = 4033 \text{ Bales}$$

use 4100 Bales

4100 Bales @ \$0.75/Bale

\$ 3,075.00

Cost of Transport from Lac La Biche at 525 Bales per Load going a distance of 330 km at \$1.86/km results in a cost of

\$ 4,464.00

TOTAL

\$38,267.50

Unit cost $\$38,267.50 \div 12,300 = \$3.11/\text{m}.$

NOTE: This portion of the cost estimate is based on hauling coal from a mine in the Egg Lake area.

Table B-4

OPERATING AND MAINTENANCE
FULL DISTRIBUTION SYSTEM
COST ESTIMATE

Labour		15,000
Vehicle		9,000
Odorant		100
Equipment repairs		
- meter (10%)	2,300	
- RMO station (10%)	1,600	
- distribution piping (1%)	<u>2,800</u>	
		<u>6,700</u>
TOTAL		30,800

Table B-5

OPERATING AND MAINTENANCE

MAJOR LOADS ONLY

COST ESTIMATE

Labour	15,000
Vehicle	9,000
Odorant	100
Equipment repairs	
- meters (10%)	300
- RMO station (10%)	800
- distribution piping (1%)	<u>1,100</u>
	<u>2,200</u>
TOTAL	26,300

Table B-6

CONVERSION COST ESTIMATE

The cost of converting the heating system for a residential dwelling in Chipewyan Lake is based on the following assumptions:

1. The home is presently heated by a wood space heater.
2. The new forced air duct work would involve one overhead run hung on the warm side of the ceiling.
3. The gas piping inside the home would run on the floor along the wall perimeter to the gas furnace.
4. The electrical connections for the furnace involves a minimum amount of wiring and an off-on switch. The remaining electrical controls are included in the price of the furnace.
5. The installation crew transports the furnace with them and has the required material and training to complete the installation in one day.

	<u>Full System</u>	<u>Major Load</u>
Mileage to and from Fort McMurray	\$ 250.00	\$ 250.00
Supply and install 205,461. Gigajoule furnace complete with duct-work.	1,600.00	1,600.00
Steel piping from meter to furnace	450.00	450.00
Electrical Connection	150.00	150.00
	<u>\$2,450.00</u>	<u>\$2,450.00</u>
Distribution sign-up charge	500.00	500.00
TOTAL	<u>\$2,950.00</u>	<u>\$2,950.00</u>

The cost of converting propane to natural gas for the school in Chipewyan Lake is as follows:

Material	\$ 50.00	\$ 500.00
Labour	250.00	250.00
Mileage	250.00	250.00
TOTAL	<u>\$1,000.00</u>	<u>\$1,000.00</u>
Distribution Contribution	51,341.00	74,198.00
TOTAL	<u>\$52,341.00</u>	<u>\$75,198.00</u>

Table B-6

CONVERSION COST ESTIMATE (Cont'd)

The cost of converting the diesel driven electric power plant to natural gas driven system is as follows:

	<u>Full System</u>	<u>Major Load</u>
Natural Gas Engines 2 x 50 kw @ \$500/kw	\$ 50,000.00	\$ 50,000.00
(Assume salvage value of diesels = installation cost)		
	<u> .</u>	<u> .</u>
	\$ 50,000.00	\$ 50,000.00
Distribution Capital Contribution	<u>\$ 46,750.00</u>	<u>\$ 67,528.00</u>
TOTAL	\$ 96,750.00	\$117,528.00

SECTION	GRANTS	DATE OF ISSUE	1979 03 20	INDEX	6.4
SUBJECT	Grants for Regulator-Meter-Odorizer Stations	REPLACING		PAGE	1 of 1
6.4.1	The cost of constructing, upgrading, or replacing regulator-meter-odorizer stations, will be covered by a special 100 per cent grant.				
6.4.2	Notwithstanding subsection 6.4.1 above:- (a) a portion of the cost of constructing, upgrading or replacing stations may be deemed non-grantable if the station serves a distribution system containing non-grantable consumers. (b) Where a regulator-meter-odorizer station is to be constructed, upgraded or replaced for the sole purpose of serving a non-grantable consumer, then the total cost of constructing, upgrading, or replacing shall be non-grantable. (c) Where a regulator-meter-odorizer station is to be constructed, upgraded or replaced in a rural gas utility which will not purchase gas, from the source on which the regulator-meter-odorizer station is located, from Gas Alberta, then the total cost of constructing, upgrading, or replacing shall be capitalized under the normal grant structure for farm consumers.				
REFERENCE					

UTILITIES AND TELEPHONES

SECTION	GRANTS	DATE OF ISSUE	1979 03 20	INDEX	6.2												
SUBJECT	Normal Grant Structure for Farm Consumers	REPLACING		PAGE	1 of 1												
6.2.1	The capital cost per farm consumer is calculated by dividing the total rural capital costs by the total number of farm consumers. The grant per farm consumer is then calculated from the following table using the quotient established from the method described above.																
6.2.2	<table><tr><td><u>Capital Cost Per Farm Consumer</u></td><td><u>Sharing of Capital Costs</u></td></tr><tr><td>Up to \$1700</td><td>100% Distributor</td></tr><tr><td>Over \$1700 to \$3000</td><td>100% Grant</td></tr><tr><td>Over \$3000 to \$4500</td><td>25% Distributor- 75% Grant</td></tr><tr><td>Over \$4500 to \$8500</td><td>10% Distributor - 90% Grant</td></tr><tr><td>Over \$8500</td><td>100% Distributor</td></tr></table>					<u>Capital Cost Per Farm Consumer</u>	<u>Sharing of Capital Costs</u>	Up to \$1700	100% Distributor	Over \$1700 to \$3000	100% Grant	Over \$3000 to \$4500	25% Distributor- 75% Grant	Over \$4500 to \$8500	10% Distributor - 90% Grant	Over \$8500	100% Distributor
<u>Capital Cost Per Farm Consumer</u>	<u>Sharing of Capital Costs</u>																
Up to \$1700	100% Distributor																
Over \$1700 to \$3000	100% Grant																
Over \$3000 to \$4500	25% Distributor- 75% Grant																
Over \$4500 to \$8500	10% Distributor - 90% Grant																
Over \$8500	100% Distributor																
REFERENCE																	

